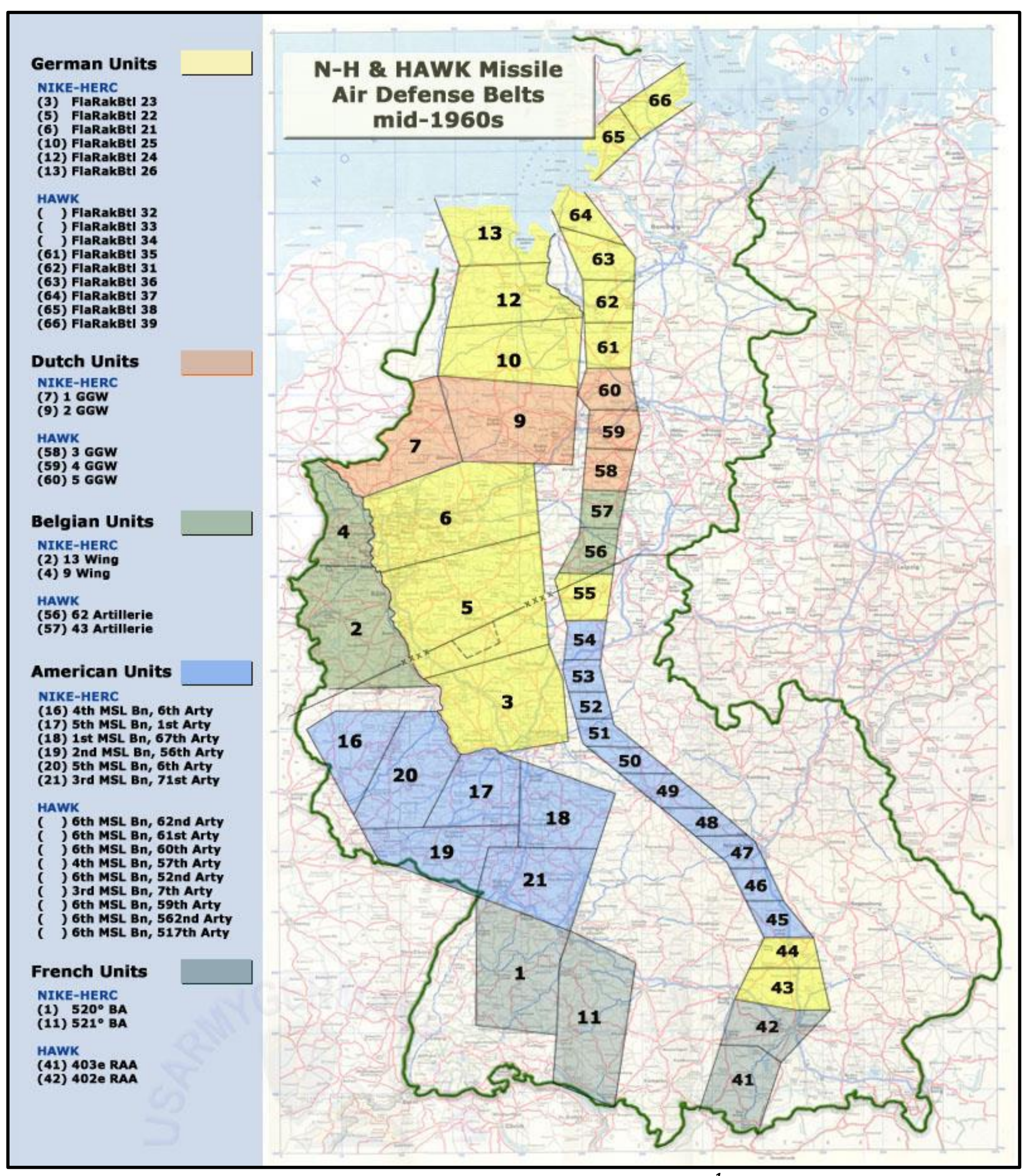
MIM-23 HAWK

The development of the HAWK started in the early ‘50s in US and entered in service in US Army in 1959 and 1960 in USMC. It was a very advanced system in its time many of new technology advancements were applied first for HAWK (almost a decade earlier comparing to Soviet SAM systems). The name of the system is an acronym HAWK means **H**oming **A**ll the **W**ay **K**iller. Many sources call system “Hawk” which is incorrect the system was not named about a bird.



Above are the sites of HAWK batteries in West Germany during the Cold War[1]. The site locations tell something about how the NATO planned defending against the attack of Warsaw Pact. The HAWK barrier was not at the border of East and West Germany. As we can judge in early stages of an imagined war NATO planned to give up territory because the border region mostly is not under protection HAWK SAMs.

[1] https://bit.ly/2rN9GTo

The HAWK is not a classical homeland SAM system only a minimal quantity was deployed on US soil in Florida close to Cuba. Similar to Soviet S-75 and S-125 HAWK is deployable – moreover it is much mobile, see later – but in West Germany all HAWK got hardened sites forming a 900 km long SAM barrier. [2]

HAWK was used by most of NATO member countries and literally all US friendly countries with a little euphemism we can say it was the "SA-2 of the western world". Hundreds of batteries were manufactured with more than 40 000 missiles from different variants. Similar to SA-2 or other Soviet SAM families the HAWK got upgrades during its very long career but the changes were more serious in many cases than for Soviet SAMs.

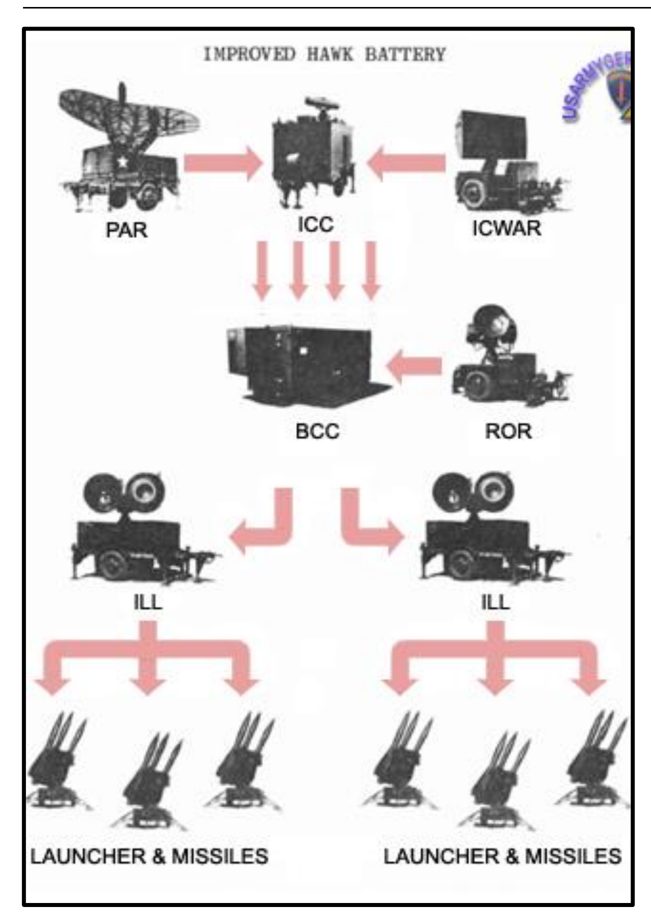
When HAWK started its service it was more advanced than any contemporary Soviet SA-2 family (SA-75/S-75) or the SA-3 family (S-125) variant but in some features they were similar. HAWK also used different radars for different purposes but the used guidance and antenna type HAWK was much more advanced. The fire control radar of the HAWK used a continuous wave (CW) and the antenna was monopulse type which ensured far better electronic jam resistance; even the US was not able to jam such radars until mid '70s. (Monopulse antenna makes radar immune the angle deception jamming method.) The low level search radar also used a continuous wave which provided very good search capability against targets in ground clutter or a low level. The first Soviet SAM with low level CW search radar was the S-300PT (5N66 Clam Shell) which entered in service only in 1978 (in a more advanced form).

Besides being more advanced in electronics the missile of the HAWK was simpler than the most widely used Russian missiles of S-75/125 it had only a single stage it did not have booster stage. Also was very important difference between the HAWK and traveling stage of Dvina/Volkhov missiles. The Soviet SAM used very toxic two component liquid propellant which meant much complicated and more equipment demanding service operations for the crew.

Considering against tactical aircraft first version of HAWK had similar engagement range to S-125M1 Neva maximal engagement range was 25 km up to 11 km altitude; upgraded variant with different missile have 35 or 40 km range up to 18 km altitude which was similar to SA-75 Dvina. The main elements of the HAWK were the followings:

1 x PAR ***Pulse Acquisition Radar***	*Target acquisition radar against medium and high flying targets*
1 x CWAR ***Continuous Wave Acquisition Radar***	*Continuous wave target acquisition radar against low level targets*
2 x HPIR ***High Power Illuminator Doppler Radar***	*Continuous wave fire control radar against low level targets with monopulse antenna*
1xROR ***Range Only Radar***	*Target distance meter radar, pulse radar. It was used only in case other radars are jammed The ROR used different wavelength than other radars of the battery. (The Nike Hercules and the S-75+Amazonka represented same conception.)*
6 x M192	*Missile launcher with 3 pcs missiles.*
12 x M390	*Missile transporter with 3 pcs missiles*
(18+36) x MIM-23	*Solid fuel single stage missile; 18 missiles are on launchers, 36 missiles on transporters / full battery*
1 x BCC ***Battery Control Central***	*Battery command element, the human-machine interface*
1x ICC ***Information Coordination Central***	*ICC process the data from radars and transfer to BCC; communications also installed in ICC as well as the IFF equipment.*
1 x PCP ***Platoon Command Post***	*For later HAWK variant performed tasks of the ICC, it has 3 men crew.*

[2] https://goo.gl/VFUACf



On the image left is the main equipment of Improved HAWK (I-HAWK) battery; in fact the battery is not a single unit it consist two fire sections. A part of the battery can be detached from the rest of equipment to create the assault fire unit. (AFU) In the AFU are 3xM192 launchers, 1xCWAR, 1xHIPIR (it has “ILL” label on the image left, ILL = illuminator) and the 1xPCP also moves with the detached part of the battery.

In this configuration AFU can act as a smaller mobile unit which suits better to be an army air defense system (using the Soviet term). In this configuration the AFU has only a single target channel comparing to the 2 channels of a full battery. In case AFU is not detached the ICC does not have crew it acts only a comm/data center for BCC.

In normal operation the tactical control officer (TCO) in the BCC supervise the work of the full crew. The core guidance crew is 5 men including the TCO (1 TCO + 2x2 men for the two target channels).

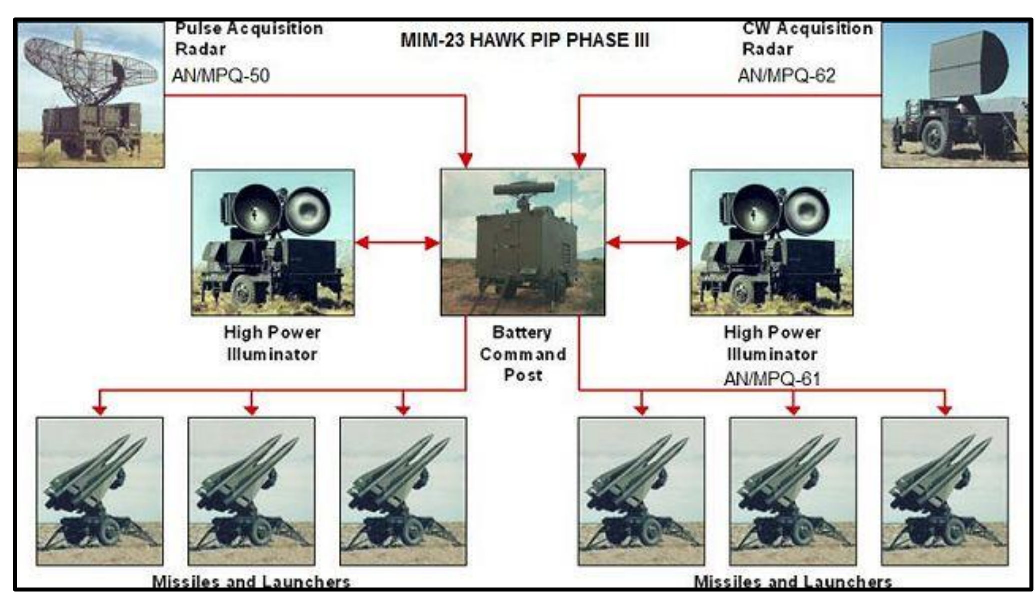
The HAWK was a very mobile system comparing to SA-2 and SA-3 family moreover the main elements where so small and light it could be airlifted by large transport helicopter such as CH-47 Chinook. The HAWK can be deployed to such locations which cannot be reached on road or even on terrain.

The MIM-23A missile had M22E8 solid fuel rocket engine with 25-32 seconds burn time with 25 km maximal engagement range and 2 km minimal engagement range. From the MIM-23B the missile had M112 type dual-thrust rocket engine; after 5 seconds of initial very high thrust in the traveling phase for 21 seconds provided smaller thrust but the total impulse of the engine became higher. Besides new rocket engine the warhead weight slightly was increased to 75 kg the total mass of the missile was increased from about 585 kg to 635 kg. The engagement range was increased to 35 or 40 km (depending on source) the maximal altitude to 18 km, the minimal engagement distance was reduced to 1.5 km which was exceptionally good in that time.

The kinematic parameters of later missile variants did not change seriously the missile got other improvements. The maximal overload capability of the missile was 15G which was far better than any SAM had in the ‘60s (Soviet SAMs had about 6-9G in this era.) The weight and dimensions of the missiles especially the non-toxic solid propellant made much more easily serviceable the missiles comparing to SA-2 family. (Weight of SA-2’s missile was about 2.2-2.4 tons, even the smaller Neva was almost 1 ton.) The missile had much smaller warhead than Soviet missiles with RCG guidance because the accuracy of SARH guidance is not distance dependent.

Thanks to the CW fire control radar with semi active radar homing (SARH) guidance the minimal engagement altitude was only 60 meters which was exceptionally good in the early ‘60s when first generation of RCG guided SAMs many times had kilometer scale minimal engagement altitude both in US and the Soviet Union.

SA-2A/SA-75 Dvina had 3000 meters engagement range, the SA-2C/S-75 Desna had 500 meters, SA-2E/S-75M Volkhov had 300 meters even in early '70s the SA-2E/S-75M2 still had 100 meters. The SA-3A/S-125 which was designed against low level targets had initially 300 meters minimal altitude only SA-3B/S-125M reached 50 meters and S-125M1 to 20 meters but the minimal engagement range of the Neva was 3.5 km because of the booster stage of the missile which does not allow any maneuver until they have not beet jettisoned. (Dvina/Volhkov had 5/7 km minimal range.)



Main components of the HAWK battery in Phase III configuration





For the system was designed self-propelled missile launcher but it remained in test phase never entered in service the project was cancelled in 1971. Above left is the M192 launcher.

Since the first variant the HAWK got many upgrades thanks to the changes different kind and quantity of radars were used see them in the chart below.

<table>
<tr><th>IOC</th><th>Type</th><th>PAR</th><th>CWAR</th><th>HPI</th><th>ROR</th></tr>
<tr><td>1959</td><td>Basic HAWK</td><td>AN/MPQ-35</td><td>AN/MPQ-34</td><td>AN/MPQ-33/39</td><td>AN/MPQ-37</td></tr>
<tr><td>1972</td><td>Improved HAWK</td><td rowspan="4">AN/MPQ-50</td><td>AN/MPQ-48</td><td rowspan="2">AN/MPQ-46</td><td rowspan="3">AN/MPQ-51</td></tr>
<tr><td>1979</td><td>PIP Phase I</td><td rowspan="2">AN/MPQ-55</td></tr>
<tr><td>1983</td><td>PIP Phase II</td><td>AN/MPQ-57</td></tr>
<tr><td>1989</td><td>PIP Phase III</td><td>AN/MPQ-62</td><td>AN/MPQ-61</td><td>-</td></tr>
<tr><td></td><td>HAWK XXI</td><td>AN/APQ-64</td><td>-</td><td>AN/MPQ-61</td><td>-</td></tr>
</table>

One of the main changes during the upgrades in Phase III configuration the ROR radar was not necessary anymore. In HAWK XXI configuration only two radars are used; for target acquisition is the AN/APG-65 Sentinel (3D electronically scanned, LPI capable).

The function of the BCC, ICC and PCC is replaced by a single unit the Fire Distribution Center (FDC).PIP III Phase HAWK variant enjoyed the benefits the advancements of the digital era and solid state electronics FDC was a key upgrade to be part of an IADS with Patriot batteries to be able to share and get data from the new SAM system. Replacement of the vacuum tube technology started in Phase II. Of course not only the radars other electronics also got upgrades as well as the missiles:

Generation and capability	***IOC***	***Missile type***
Basic Hawk	1959	(M3), MIM-23A
I-HAWK	1971	MIM-23B
Improved ECCM	1982	MIM-23C/D
Low-level/ multi-jamming	1990	MIM-23E/F
New body section	early '90s	MIM-23G/H
New warhead and fuzing for anti-TBM capability	1995	MIM-23K/J
New fuzing only, old warhead	1995	MIM-23L/M

Following the upgrades the HAWK had remarkable features even in the late '70s which for the Patriot system became even more pronounced. The central processing unit and computer of the HAWK made possible instead the full manual operation (target sorting, target selection, illumination and guidance tasks) the semi-automatic operation mode[3] where the crew is mostly supervised/managed the system similar to later Patriot. The crew just could gave priorities the system to have a "to be engaged queue"; the system was able to launch missile in semi-auto mode. The features and automatization was not on the same level as for the Patriot but the upgrade showed the dawn of a new era.

The Phase III HAWK was able to shoot down tactical ballistic missile (TBM) according to fire range tests but obviously this capability could be done only in semi-auto mode with small offset distance parameter and much smaller engagement range comparing to subsonic aircraft.[4] Ballistic missiles have to be tracked from much bigger range than maximal engagement range to be determining the impact point to have enough time for the engagement procedure and missile reach the target in time.

The US Army retired the HAWK in the middle of '90s the USMC used until 2002. Regardless the USA does not use anymore many countries still keep in service different variants of HAWK. HAWK XXI variant is used in Turkey, South Korea and Romania but older PIP II/III types are still in service in more than 20 countries. HAWK was so strongly upgraded it survived all of its contemporary Soviet SAM system such as SA-75/S-75 (SA-2 family) and S-125 (SA-3 family). These old Soviet SAMs today (in 2018) are used mostly poor and 3rd World countries while the HAWK is still being used in the Western world.

The HAWK is not a widely known[5] SAM system because it was not as widely used in real combat as Soviet SAMs in the conflicts of Cold War. The HAWK was used in Iraq-Iran War (1980-1988) and by Israel in 4th and 5th (1973, 1982) Arab-Israeli Wars and Kuwait in 1990 but sources about these are very limited. The most known combat action of the HAWK happened under Israeli flag it damaged a MiG-25 which later was downed by and F-15 Eagle.

[3] *https://youtu.be/85n8MbTh5mI?t=4m14s*

[4] *See the meaning of the term at Russian SAMs.*

[5] *As I can judge it.*

In 1973 Israeli HAWKs with 63 missiles during 32 engagements downed 22 Arab aircraft.[6] (Israel had 12 HAWK batteries with 24 fire channels.) This is far better statistics compared to any Soviet SAM system concerning a single conflict during the Cold War it means 68% engagement success rate and 34% hit rate assuming every time only a single missile hit the target. (See in another chapter about statistics of some conflicts.)

The most similar Soviet SAM to HAWK is the 2K12 Kub (SA-6). The Kub uses too SARH guidance with CW fire control radar, monopulse antenna and solid fueled missile. It was designed for army air defense role which means it is a mobile SAM system. All main elements are installed on tracked self-propelled vehicles which provide good mobility even on rough terrain but comparing to HAWK it could not be airlifted by helicopters.

The first HAWK entered in service in 1959/60 while the first Kub variant reached IOC in 1967, the first mass produced Kub version the 2K12M1 was available only from very 1973.

We can see again what has been mentioned. Most of people are amazed on Soviet SAMs while the US was in some areas decades comparing to Soviet Union such as using SARH guidance instead RCG, using CW illumination instead pulse radar, using monopulse antenna to eliminate some jamming methods, using solid rocket fuel instead liquid fuel.

[6] *https://www.cia.gov/library/readingroom/docs/LOC-HAK-480-3-1-4.pdf*